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The Impact of the 2005 Collective Bargaining Agreement on Competitive Balance in the National Hockey League

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by

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Abstract

After a lockout that canceled the 2004-05 season in the National Hockey League (NHL), the owners and players reached a collective bargaining agreement (CBA) that instituted a 'hard' salary cap, a modified revenue sharing system, and changes in free agency. The principal motivation for the new agreement was to raise competitiveness among the teams, in order to generate greater revenue and profitability and to support higher player salaries. The purpose of this study is to evaluate the impact of the CBA on competitive balance within the NHL and identify the principal determinants of the changes in competitiveness among the teams.

We evaluate several alternative measures of competitive balance: dispersion in point percentage; the Herfindahl-Hirschman index; the Gini Index; number of playoff games; and number of times a team has made the playoffs. We then develop and estimate alternative models of the determinants of point percentage (equal to points earned by a team divided by total possible points), in which point percentage is hypothesized to be a function of team payroll (a proxy for player talent) and free agent signings.

We estimate the models using a sample of all 30 teams in the NHL across eleven seasons, including five seasons prior to the 2005 CBA (2000-2004) and six seasons after its implementation (2006-2011). We find that the new CBA has increased competitive balance, primarily because of a reduced impact of team payroll on point percentage and the facilitation of free agent signings which have more nearly equalized the talent across teams.

Table of Contents

List of Exhibits

Chapter 1
Introduction

Purpose of the Study

In all professional sports, competitive balance is an important and desirable attribute to have within the League. All of the major American professional sports leagues are always looking for ways to increase competitive balance by changing the rules that govern their sport. Prior to 2004, the National Football League (NFL), the Major League Baseball (MLB), and National Basketball League (NBA) all had payroll mechanisms and revenue sharing plans to help increase its competitive balance. Because the National Hockey League was the only major professional League that did not have any of these provisions in its Collective Bargaining Agreement (CBA), the resulting lack of competitive balance may have contributed to lower profits. Competitive balance is important as it increases the quality of play between teams, raises fan interest and attendance, and leads to more lucrative television deals, all of which generate higher revenue and profitability. (Neale)

The purpose of this study is to evaluate the magnitude and causes of the change in competitive balance within the League since the institution of the 2005 CBA, which added payroll mechanisms and a revenue sharing plan.

This research is also important as the current CBA is set to expire at the end of the 2011-12 season. Without a doubt, the League owners and players union will sit down together to discuss the state of the NHL. In doing so, one of the concepts that will be discussed is the competitive balance of the League. They will look to see if the changes they made positively or negatively affected the game and the profits of the League. If there is a positive effect, then there is a chance they could include

more payroll mechanisms or a different revenue sharing plan to further increase the effects on competitive balance. If negative effects are found, then they will know that a different system is necessary.

Outline of the Study

In the second chapter we will look into the institutional and historical context of competitive balance. We will introduce various ways payroll can be controlled by the League, including different salary caps and salary floors. We will also indulge into revenue sharing plans and their purpose of spreading League wealth. Finally, we will describe the important changes in the 2005 NHL Collective Bargaining Agreement.

In the third chapter we first examine alternative measures of competitive balance, including standard deviation of point percentage, a Herfindahl-Hirschman Index, distribution of wins, number of playoff games, number of times a team makes the playoffs, and a comparison to the previous season's point percentage. We then will examine the determinants of competitive balance, including the institution of the salary cap, revenue sharing, and changes in free agency. We will end with the introduction of the simple model, using point percentage as the dependent variable and payroll and free agent signings as the dependent variables.

In the fourth chapter, we introduce the sources of the sample. Next, we estimate and analyze the various measures of competitive balance. Lastly, we estimate the model and review various regression results.

In the final chapter, we conclude that competitive balance has improved as a result of the 2005 CBA. Also, we find that the impact of the changes in the CBA equalized the capacity of teams to acquire players of talent, which were the driving forces in the improvement of the League's competitive balance.

Chapter 2
Evolution of the Collective Bargaining Agreement

In this chapter, we begin by introducing various ways payroll can be controlled by the League, including different salary caps and salary floors. We then will introduce revenue sharing plans and their purpose of spreading League wealth. Finally, we will introduce the 2005 NHL Collective Bargaining Agreement and detail the important changes.

Concepts of Competitive Balance

Competitive balance in any market is described as a market situation where no business is too big or has an unfair advantage. (Financial Times Lexicon) In sports, it can be much different. There are many ways in which competitive balance has been studied. In general, competitive balance shows the uncertainty in sporting events.

In professional sports leagues, there are two types of competitive imbalance. (Sanderson and Siegfried, 2003) One is where the large market teams with lots of money acquire all of the best players. This is the most common form of imbalance and the one that this paper addresses directly. There are many methods that can be used to control competitive balance. Some of the methods that have been used in professional sports leagues are payroll mechanisms and revenue sharing plans.

Ways to Limit the Size of Payroll

Payroll mechanisms are used to place boundaries on the amount of money that a team can spend on payroll. A 'salary cap' is an example of one of these mechanisms. This prevents the richer teams from over-paying players to get them to come and play for them. There are two types of salary caps, 'hard' caps and 'soft' caps. A hard cap is what the NFL uses.[1] With a hard cap, team payroll cannot exceed the limit for any reason whatsoever. This cap is usually calculated as a percentage of league revenue. The soft cap is different in that teams can exceed the limit under certain circumstances. In the NBA, a team can exceed the cap in order to resign a player who is already on the team. (Castillo, 2010) This is done to prevent big name players from changing teams a lot, which could lead to fans becoming disinterested. This cap still prevents teams from going into free agency to sign the best players. The MLB also uses a type of a soft cap called a luxury tax.[2] With this system, teams are taxed a certain percentage for every dollar they go above the cap. With this system, richer teams are still able to acquire the better players, as long as they are willing to pay the tax.

Another payroll mechanism similar to a salary cap is a salary floor. This is a lower limit of team salary that every team must meet. The idea here is to force teams to spend money on players to become more competitive. There are pros and cons to using a salary floor. One pro is that it forces owners to sign players, which will help them to improve. The major con is that it can force a team to overpay for

[1]http://images.nflplayers.com/mediaResources/files/PDFs/General/NFL%20COLLECTIVE%20BARGAINING%20AGREEMENT%202006%20-%202012.pdf
[2] http://mlbplayers.mlb.com/pa/pdf/cba_english.pdf

mediocre players, which will not help to increase the competitiveness of the team. They will not get the best performance for the amount of money they are spending. Thus, the team will still be uncompetitive.

Revenue Sharing

A League can also use revenue sharing techniques to increase competitive balance. The idea behind revenue sharing is to give all teams an equal chance to retain and sign players. This will help the poorer teams to sign expensive players. There are many ways a League can institute revenue sharing. One way is to have every team contribute a percentage of its revenues into a pot each season. This pot will then be equally distributed among all of the teams. Under this system, a rich team will pay more to the pool, but will receive the same amount as a poorer team. This system is used in the MLB.[3] The strongest revenue sharing plan is the one used in the NFL.[4] This is similar to the MLB in that all the League revenue is split evenly among all the teams. The NFL also uses a gate revenue sharing system. (Szymanski and Kessenne, 2004) In this situation, a certain percentage of revenues from games are put into a pool. This pool is then also equally divided amongst teams. Since the NFL makes so much money from broadcasting games on national television, the poorer teams receive more than enough money needed to build and support a strong franchise.

[3] http://mlbplayers.mlb.com/pa/pdf/cba_english.pdf
[4]http://images.nflplayers.com/mediaResources/files/PDFs/General/NFL%20COLLECTIVE%20BARGAINING%20AGREEMENT%202006%20-%202012.pdf

Although it is still tough to stop richer teams from getting better players, all of the above mentioned plans could work to help make the poorer teams more competitive. This is something that the NHL was missing out on before its new CBA in 2005.

The 2005 NHL Collective Bargaining Agreement

Before the 2005 Collective Bargaining Agreement, the NHL was the only professional sports league of the four major ones that had no salary cap, salary floor, or revenue sharing system. One of the main causes of the 2004-2005 lockout was the escalating player salaries. The League wanted a salary cap that was linked to league revenues. This would help to stabilize league profits, and to increase the competitive balance of the League. The League had lost $273 million in the 2002-2003 season. (Bissonnette, 2007) The lack of salary cap and revenue sharing made it hard for poorer teams to compete with the richer teams. Before the 2004-2005 season started, a new CBA was needed. The League and the National Hockey League Player's Association (NHLPA) went back and forth with offers. The League wanted a hard salary cap and revenue sharing similar to MLS. The NHLPA denied these offers and instead proposed a system with luxury taxes, a rollback in player salaries, and a change to the League's entry-level system. The two sides were not close to coming to a conclusion, which caused the 2004-2005 lockout. Negotiations between the two sides carried on for months and it did not look like an end was in sight. The lockout was resolved when the League agreed to put in a revenue sharing plan, in which the top ten moneymaking clubs must put money in a pool to be distributed to

the bottom fifteen teams (in terms of revenue). These bottom teams have to have a market with 2.5 million television households or less, in order to be eligible for revenue sharing.

As a result of the agreement, the NHLPA agreed to a hard salary cap that would be tied to League revenues. No teams were allowed to exceed the salary cap for any reason other than to replace a long-term injury. For the 2005-2006 season, the cap was set at $39 million. League revenues have increased every year since the lockout, leading to an increase in the salary cap as well. In the most recently completed season, 2009-2010, the salary cap was $56.8 million.

Along with the salary cap, the NHL also decided to put in a salary floor. No team is permitted to have a team payroll below the salary floor. Originally, the plan was to have the floor set to 55% of the salary cap. Over time, with an increase in revenues, the League decided to have it set at $16 million below the cap. In the 2009-2010 season, the salary floor was $40.8 million.

Under the new CBA, there were also big changes in free agency; most notably players become unrestricted free agents. Each of the four years following the new CBA, the unrestricted free agents got younger. The minimum age at which a player can shop himself on the open market was 31 years old in 2005, 29 years old in 2006, 28 years old in 2007, and 27 years old in 2008 and beyond.[5] This has allowed teams to go after players at a younger age, when they are more valuable and can help make a team become more competitive.

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[5] All information on the 2005 CBA was found at two sources:
http://www.nhl.com/ice/page.htm?id=26366
http://www.nhl.com/cba/2005-CBA.pdf

With the changes, the League was hoping to control player salaries, and therefore costs. They were also looking to increase competitive balance in order to increase revenues and profits.

In this study, we will see if competitive balance in the NHL has changed since the institution of the 2005 CBA. Furthermore, we will analyze the causes of the change in competitive balance by looking at the institution of the salary restrictions, revenue sharing plan, and free agency rule changes.

Chapter 3
Measures and Determinants of Competitive Balance

In this chapter, we will introduce the various measure and determinants of competitive balance that are used in this study. Alternative measures include a standard deviation of point percentage, a Herfindahl-Hirschman Index, a Gini- Index, distribution of wins, number of playoff games, number of times a team makes the playoffs, and a comparison to the previous season point percentage. The determinants that we will focus on include the institution of the salary cap, revenue sharing, and changes in free agency. We will end with a simple model statement, which uses point percentage as the dependent variable and payroll and free agent signings as the independent variables.

Defining Point Percentage

The most often used measure of competitive balance is winning percentage. This is because it is one of the best measures of a team's success. If teams have a high winning percentage, they are doing well in the standings. We will use a similar measure, with a small difference. We will use the point percentage of a team as a measure. In a competition, a team gets 2 points for a win, 1 point for an overtime loss, tie, or shoot-out loss, and 0 points for a loss in regulation. The point percentage is calculated as follows.

$$\text{Point Percentage} = \frac{\text{Total Number of Points}}{\text{Total Possible Points}}$$

For any team, the total possible points is equal to 2*n, where n is the number of games played. The reason this method is used is because losing a game while still

getting a point will affect placement in the standings. Thus, it is important to include these points in the measures. Also, an overtime loss or shootout loss shows that the game was only decided by one goal, meaning it was a competitive match. A loss in regulation can be by much more, and shows less competition in the match. For these reasons, point percentage will be used as a measure of team performance.

Alternative Measures of Competitive Balance

Spread of Point Percentage

One measure is looking at the standard deviation of team point percentage. The further spread out the data is, the less competitive the League is. For perfect competitive balance, this number would be zero. This is just a basic measure that will only be able to tell part of the story.

Point Percentage Compared to an Ideal Standard

Another similar measure compares team-point percentage to an ideal standard. This is done in previous works that have measured competitive balance. (Richardson, 2000 and Leeds and Allmen, 2002) In each game, under perfect competiveness, a team has a probability of .5 of winning. Thus, the ideal measure is equal to .5/sqrt(n) where n is the number of games each teams plays. (Leeds and Allmen, 2002) In the NHL 82 games are played, so this ideal measure of point percentage standard deviation would be .5/sqrt(n) = .5/sqrt(82) = .055216. So, in order to use the measure, each team's point percentage will be divided by this ideal

standard. Then, the standard deviation of these will be taken. Once we have this, we can use the formula below.

$$\text{Ratio} = \text{SD of } \frac{\text{team point-percentage}}{\text{ideal standard}}$$

This is a good measure to use because it will show how spread out the teams are from an 'ideal' spread of point percentage.

There is another measure of competitive balance using a different ideal standard. This measure accounts for ties. Before the NHL lockout, if the game ended in a tie after overtime, then the game would be recorded as a tie. After the lockout, the game would go to a shoot-out to determine the winner. This causes a difference in point percentage from the previous 'ideal' standard. This measure does so by looking at the probability of a tie. Under equal playing strength, this standard deviation is equal to (1-p/4n)^1/2 where n is the number of teams and p is the probability of a tie. (Richardson, 2000) Since ties have been eliminated as a result of the new CBA, this may cause a problem when comparing the data before and after the lockout. Also, there is no set probability for a tie. This means data from previous seasons must be used to see what the historical probability has been. If seven years of data previous to the lockout are used, the probability of a tie is 13.41%.[6] This would make the equation become (1-p/4n)^1/2 = (1.1341/4(82))^1/2 = .0514. After the lockout, this value becomes (1-p/4n)^1/2 = (1/4(82))^1/2 = .055216. Each team's point percentage will be divided by this value, and then the standard deviation will be taken.

[6] http://www.nhl.com/ice/standings.htm?season=20032004. There is a drop down menu to scroll through previous seasons.

Using both of these different ideal standards, we will see if the change in competitive balance depends on the 'ideal' measure that is used.

Herfindahl-Hirschman Index

Another way to measure competitive balance is to consider the distribution of the number of wins, rather than point percentage. The Herfindahl-Hirschman (H-H) Index measures inequality in match and championship outcome and is given by:

$$HHI = \Sigma(MS_i)^2$$

where MS is the market share of the i^{th} firm. In this case, the market share for a team is its number of wins divided by the total number of wins by all teams:

$$HHI = \Sigma(W_{it}/\Sigma W_{it})^2$$

where W is the number of wins by the i^{th} team in the t^{th} year . (Owen, Ryan, and Weatherson, 2006) The closer that this measure is to 0, the closer the League is to perfect equality.

Gini-Index/ Quintile Approach

Another measure uses the Gini-index. This method was previously used to look at the effect that the institution of a hard salary cap had on competitive balance in the NFL. (Sommers et al, 2004) This measure is used by ranking teams in order of number of wins. Then, we do the following calculation;

$$\text{Gini index} = \sum (f_i * y_{i+1} - f_{i+1} * y_i),$$

where f is the cumulative percentage of teams and y is the cumulative percentage of

wins. In this study, we will use this measure, but with a small change. We will use the Quintile approach where teams will be placed into 5 equal-sized groups. In a perfectly competitively balanced League, each group will have 20% of the total wins. This measure will be tested across each season to see if there is a more uniform distribution across quintiles in the seasons after the lockout.

Playoff Measures of Competitive Balance

Competitive balance can also be evaluated based on playoff performance. Although the regular season is important, most managers and players are more concerned about the playoffs. For managers, it is a chance to increase revenues and fan interest. For players, it is a chance to prove that they are the best at what they do. It is almost like another season being played.

Number of Playoff Games

A simple measure of the competitive balance is the number of playoff games that take place in a season. (Richardson, 2000) Every season, eight teams from the Eastern Conference and eight teams from the Western Conference make the playoffs. The teams are ranked based on points earned in the regular season. After they are seeded, the first seed plays the eighth seed, the second plays the seventh, and so on. This is done in each conference. The teams then play a best of seven series with the first team to four wins moving on to the next round. The more competitive a series, the more games it will take to decide a winner. The winners of each series move on and are re-seeded based on the teams that remain. There are a

total of 15 series in the playoffs. This means there can be anywhere from 60 to 105 games. The limitation of this measure is that it does not take account of the closeness of the games. If all of the games are won by one goal, then the series is more competitive than if the games were all blowouts. This will not be measured in here.

Playoff Appearances

Another measure is team shares of playoff appearances across seasons. In a perfectly balanced League, every team would make the playoffs approximately every 2 years. The formula for this Index is;

$$HHI = \Sigma(P_i)^2$$

where P is the percentage of seasons that team i has qualified for the playoffs. (Owen, Ryan, and Weatherson, 2006) As this index increases, competition decreases. The value of this index is that it looks at what every team is most concerned about, getting to the playoffs. If some teams continually make the playoffs, more frequently than others, then this will result in higher squared numbers. The only limitation in this measure is it does not really tell the whole story. Even if the same teams are making the playoffs, their rankings within the playoffs can be different from year to year. This is an aspect of competitive balance that is not measured in this index.

Previous Year's Point Percentage

The last measure that will be used shows the effect that last season's point percentage has on this year's. A simple regression model can be used:

$$PointPct = \alpha + \beta_1 PointPct_{-1} + \varepsilon,$$

where PointPct is the point percentage of the current year and $PointPct_{-1}$ is the point percentage from last year. This regression will be run across two different time periods, both before and after the lockout. In comparing the two time periods, we can see if the 2005 CBA reduced the effect, suggesting an increase in competitive balance.

Now that we have established the ways of which we will measure competitive balance, we next look at its determinants of team performance.

Determinants of Team Performance

Payroll

With the salary cap, teams will not be able to go out and spend all the money that they want. This will bring team payrolls closer together. Teams closer to the cap will not be able to sign players seeking a lot of money, while the teams with lots of 'cap room' will be able to sign those players. So, the teams in the League should have payrolls that are closer to each other. Team payroll will be compared to team point percentage to see if they share a relationship. Previous studies have looked at the relationship between team payroll and point percentage. Forrest and Simmons (2000) look at all four major sports in America to see this effect. It looks at team

payroll to see if it is a significant predictor of team success, when measured by point percentage in the regular season. It found that it was a strong predictor for all four major US sports. This should help to explain the changes in competitive balance as a result of the new CBA. Berri and Todd (2004) look at the NBA to see if team payroll affects the number of wins. They found that salary dispersion has no effect on the number of team wins. This suggests that teams are not getting what they pay for, and there are other determinants that are more important. Sommers et al. (2004) look at the effects of a hard salary cap in the NFL. This salary cap brought team payrolls closer together, but this had no effect on performance, measured by the Gini-index.

This study will experiment with the effect that payroll has on team performance. It could very well be the case that this effect is not linear, where every dollar spent has an equal effect on performance. Logarithmic and quadratic specifications will be considered to capture the true effect that payroll has. These relationships will allow us to see if there are diminishing returns to payroll on performance.

Free Agency

Next, the changes in free agency rules will be looked at to see its effect on point percentage. As noted in Chapter 2, the major changes to unrestricted free agency are as follows;

Exhibit 1: Unrestricted Free Agency Rules	
Year	Minimum Age of Unrestricted Free Agents
2005 and before	31
2006-2007	28
2007-2008	28
2008-2009 and after	27

With more players becoming unrestricted free agents, there will be more opportunities for weaker teams to pick up players that will help them be more competitive. Before this change, the players that were available were older players who do not have the same impact on team performance as the younger players. We hypothesize that the number of free agents signed by a team does have an effect on team point percentage. Although not much research has looked directly at this, there have been multiple papers on Free Agency and its effect in general. Fishman (2003) looks at free agency in the MLB. He uses a few different measures to see the effect and they show conflicting results. In general, Fishman finds that the higher the number of free agents available, the greater the effect on team performance. This has shown to help the teams that are willing to spend the money on the free agents. Other research has shown different results. Fort and Lee (2007) look at the other three major sports in America to see the effects of free agency. They find that there is no effect of free agency on the competitive balance of a League.

Free agency is also affected indirectly with a change in the CBA. This change has to do with the salary cap. It has made it harder for teams to resign players when they are up for a pay raise. If the team does not have the room, they must let them go. Thus, there will be more free agents available for teams to pursue. For both of

these reasons, weaker teams should be able to improve and become more competitive, while performance of better teams is reduced.

It is also important to note that the type of free agent signed will have different effects. In any given year, numerous free agents are available who will bring different skills to a team. Some of these players are better than others. As a result, these free agents will need to be split into groups. This is because the effect of signing two of the best players is much different from signing two of the worst. For this study, we have broken the free agents into three groups, top-end, medium-end, and low-end players. The high-end players will most likely improve a team's chances while low-end players may not even dress every game of the season.

Revenue Sharing

Finally, the addition of revenue sharing in the NHL is an important determinant of competitive balance. Revenue sharing is supposed to work by giving the poorer teams more money so that they can compete with the richer teams, when it comes to holding on to players and signing new players. This is the determinant of competitive balance that has been studied the most, and has also showed conflicting results. Some previous studies have shown revenue sharing having no effect or even a negative effect. One reason for this is because the team that receives the money does not have to spend it. If managers and owners are profit maximizing, then they may pocket the money that they receive from revenue sharing instead of investing it to increase the competitiveness of the team. Chang and Sanders (2009) found that revenue sharing led to an increase in the variance of expected winning

percentage. This is because sometimes teams in the lower half are not spending the money. As a result, the better players will go to the better teams. Vrooman (2009) argues that in order for revenue sharing to be effective, certain condition must be met. First, the League should share at least 50% of its revenue. He argues that this will lead to an increase in competitive balance. The NFL is a prime example. It shares all of its League revenue so all the teams have equal opportunity to build a winning program. Also, the owner must be more concerned with maximizing wins rather than maximizing profits so that the money received from revenue sharing will actually be used to improve the team.

Regression Model

Payroll and free agent signings will be used in the regression model, while revenue sharing will not be included. For one, there is not a good measure of revenue sharing that can be put into a regression as an independent variable. If the regression finds that payroll does have a lower effect in the seasons after the lockout, then it is reasonable to conclude that more revenue sharing will lead to more competitive balance. So, this regression will use payroll and number of free agents signed by a team as the determinants of point percentage.

The regression model is;

$$PointPct = \alpha + \beta_1 Payroll + \beta_2 TFA1 + \beta_3 TFA2 + \beta_4 TFA3$$

Where PointPct = Point percentage
Payroll = Payroll
TFA1 = top-end free agent
TFA2 = medium-end free agent
TFA3 = low end free agent

Point percentage is used as the dependent variable because it is the most appropriate measure of team performance. This regression model will be used with two different time periods, before and after the lockout. This will allow is to compare the results to see if there is a lowered effect of payroll on a team's performance. If this is the case, then we can say that the restrictions on payroll are a reason for the change in competitive balance. This model will also be able to determine the effect that signing a free agency has on point percentage. If this is positive, then we can say that changes in free agency rules is a reason for the change in competitive balance. In this model, we expect Payroll, TFA1, and TFA2 to be positive, while TFA3 to be negative.

This paper will also consider logarithmic and quadratic specifications with regards to payroll. The following two models regression models will be used.

$$\text{Exponential - } PointPct = \alpha + \beta_1 Payroll + \beta_2 Payroll^2$$
$$\text{Logarithmic - } PointPct = \alpha + \beta_1 LogPayroll$$

In considering these two models with the first one given, we should be able to capture the true effect that payroll has on a team's performance.

With these regressions, we expect to find that payroll has a lower effect after the lockout. This means that teams are not able to "buy championships" by spending more money on players than other teams. We also expect to find that signing free agents will increase a team's point percentage.

Chapter 4
Evaluation of Competitive Balance and Determinants of Team Performance

In this chapter, we will conduct the necessary estimates of the measures and determinants of competitive balance discussed in chapter 3. We first will introduce the sources of the sample. Next, each of the measures of competitive balance will be estimated and analyzed. Finally, the regression results estimating the model statement will be presented and analyzed.

Sources and Measurement of Data

Data comes from the 1999-2000 season to the 2009-2010 season plus part of the 2010-11 season (through February 18th). The 2004-05 season is not used because of the lockout. So, the data will cover the five years before and five and a half years following the lockout. For each season, the data will cover the 30 teams in the NHL. The one exception is the 1999-00 season. In this season there were only 28 teams. In the following season, the Columbus Blue Jackets and the Minnesota Wild entered the League as expansion teams.

The necessary data for each team includes; point percentage, wins, number of playoff appearances, number of playoff games, payroll, and number of free agents signed (by group). The data are collected across all 11 seasons.

To illustrate how the data set was derivied, a team, the Colorado Avalanche, will be used to walk through the steps to getting the data. First, the data that is necessary for the measure of competitive balance section will be introduced. This data includes point percentage, wins, number of playoff appearances, and the

number of playoff games. In order to get Colorado's point percentage, the NHL's main website was used.[7] An example of the calculation of point percentage is shown in Exhibit 2.

Exhibit 2: Calculation of Point Percentage

From the 2009-2010 Seasons
Wins in Regulation: 43
Losses in Regulation: 30
Over Time Losses: 9

$$\text{Point Percentage} = \frac{\text{Total Points}}{\text{Total Possible Points}},$$

$$= \frac{(2*\text{Wins}) + (\text{Ties} + \text{Overtime Losses})}{2* \text{ Games Played}}$$

$$= \frac{(2*43) + (30 + 9)}{2*80}$$

$$= .579$$

The same calculation was use to calculate the point percentage for the other seasons as well. In order to see if Colorado made the playoffs in a given year, this same website is used. In ranks the teams in order of points, and splits up the teams that made the playoffs from the teams that did not. We just looked at the standings for each year to see if Colorado was in the playoffs. To find the number of playoff games, the Hockey Nut website was used.[8] This site shows the number of games for all NHL playoffs dating back to 1996-1997.

[7] http://www.nhl.com/ice/standings.htm#?navid=nav-stn-main (drop down menu to get to previous seasons)
[8] http://www.hockeynut.com/archive.html

In order to find payroll information for the Colorado Avalanche, multiple sources of data are necessary. One source is NHLnumbers.[9] This gives Colorado's team payroll for the 2007-08 season to the 2011-2012 season. In order to get the data in early seasons, Hockey Zone Plus was used.[10] This gives Colorado's payroll information back to the 1992-1993 season. From these sites, all the payroll information is available. Finally, two sources were necessary to get information on free agent signings. One of the sources is Sports City.[11] This gives data on the number of free agents that Colorado signed in the 2008-2009 season and on. The other seasons are received at Pro Ice Hockey, which gives data for the remaining years.[12] Next, it is necessary to look up each free agent's salary to determine if they are a top, mid, or low-end free agent signing. There is one problem with the free agent signings. Information on the free agent signings in the seasons prior to the 2004-2005 season is unavailable. As a result, these seasons are not included in some of the regressions later in the chapter.

Although steps are only shown for one team, all other teams are done the same way. The descriptive statistics of the data are reported in Exhibit 3.

[9] http://nhlnumbers.com/teams/COL?year=2011
[10] http://www.hockeyzoneplus.com/$maseq_e.htm
[11] http://www.sportscity.com/nhl/2009-nhl-unrestricted-free-agents-by-position
[12] http://proicehockey.about.com/od/nhlfreeagents/a/06_transactions_3.htm

Exhibit 3: Descriptive Statistics

	00	01	02	03	04	06	07	08	09	10	11
Payroll ($millions)											
Average	31.62	33.34	38.03	42.38	43.95	34.32	40.30	44.37	53.40	54.34	56.54
Standard Deviation	9.96	10.36	12.58	13.59	15.46	6.38	4.72	7.58	4.87	4.97	5.69
Range	42.80	40.20	46.20	48.70	54.60	26.00	23.30	33.30	15.59	17.78	19.77
Point Percentage (%)											
Average	0.5249	0.5249	0.5246	0.5315	0.5295	0.5572	0.557	0.5553	0.5573	0.5613	0.5575
Standard Deviation	0.10	0.11	0.09	0.09	0.10	0.10	0.10	0.06	0.08	0.08	0.09
Range	0.46	0.40	0.38	0.32	0.31	0.41	0.35	0.27	0.34	0.36	0.37
Number of Wins											
Average	35.64	35.93	36.03	35.77	35.33	41.00	40.67	41.00	41.00	41.00	22.73
Standard Deviation	8.76	9.09	7.83	7.96	8.19	8.96	8.86	5.40	7.18	6.99	4.36
Range	37.00	31.00	32.00	30.00	28.00	37.00	31.00	23.00	29.00	27.00	16.00
Top Free Agents Signed (# of players)											
Average						0.60	0.47	0.47	0.50	0.53	.51
Standard Deviation						0.62	0.68	0.68	0.63	0.68	.64
Range						2.00	2.00	2.00	2.00	3.00	3.00
Mid Free Agents Signed (# of players)											
Average						1.53	1.73	1.33	1.37	1.30	1.35
Standard Deviation						1.14	0.94	1.03	0.96	1.06	1.04
Range						4.00	5.00	3.00	3.00	4.00	3.00
Low Free Agents Signed (# of players)											
Average						1.37	1.53	1.00	2.47	2.37	2.26
Standard Deviation						1.07	1.07	1.14	1.36	1.73	1.28
Range						3.00	4.00	5.00	6.00	6.00	5.00

Alternative Measure of Competitive Balance

Standard Deviation of Point Percentage

The first measure of Competitive Balance is the standard deviation of the point percentage across all of the seasons. The results are listed in Exhibit 4.

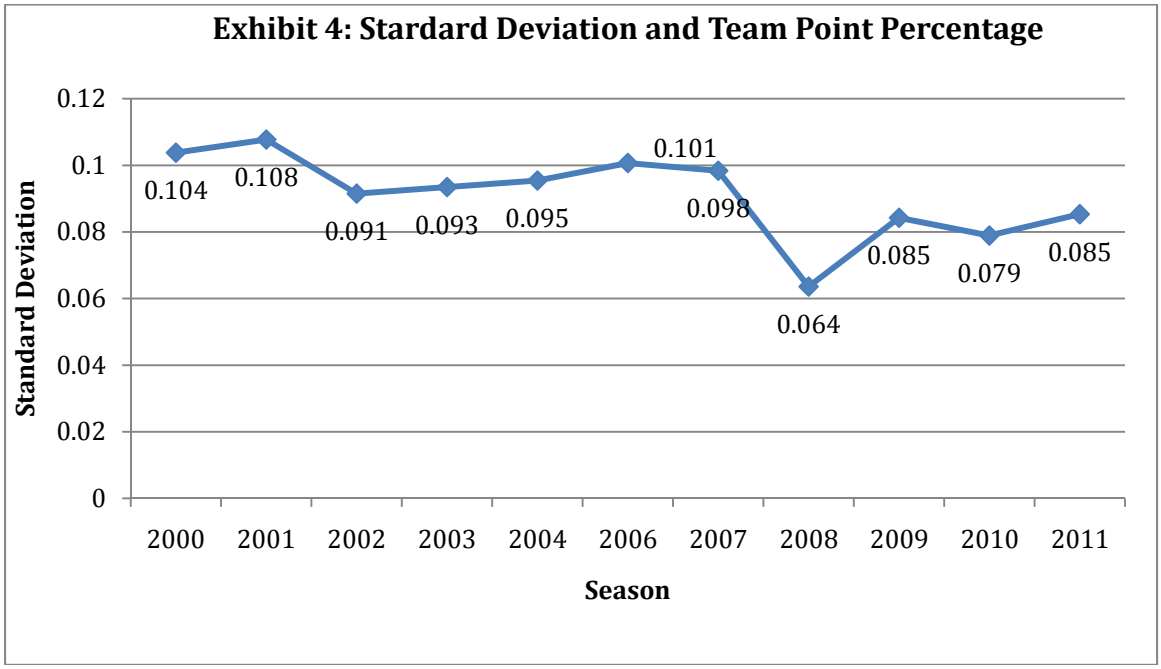
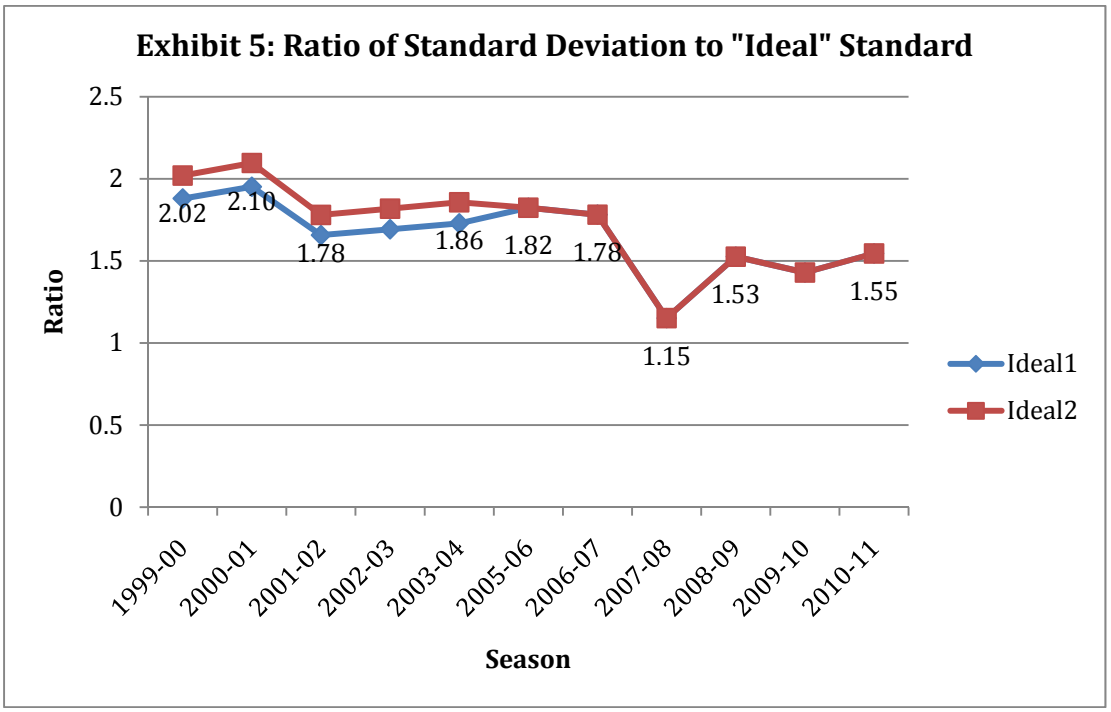


Exhibit 3 shows that the standard deviation of point percentage is steady around .1 until the lockout. After the lockout, the results seemed to be the same for a couple years, before a dramatic drop in the 2007-2008 season. In the past two seasons, the standard deviation has also been lower than before, ending at around .8 in the 2010-2011 season.

Point Percentage Compared To Ideal Standard

The next two measures compare the standard deviation of point percentage to an ideal standard. They are labeled "ideal1" and "ideal2". The difference between the two is that ideal2 includes the probability of a tie in its measure of an ideal standard. These measures divided team point percentage by the ideal standard, and then the standard deviation is taken. The results from both of these methods are shown in Exhibit 5.

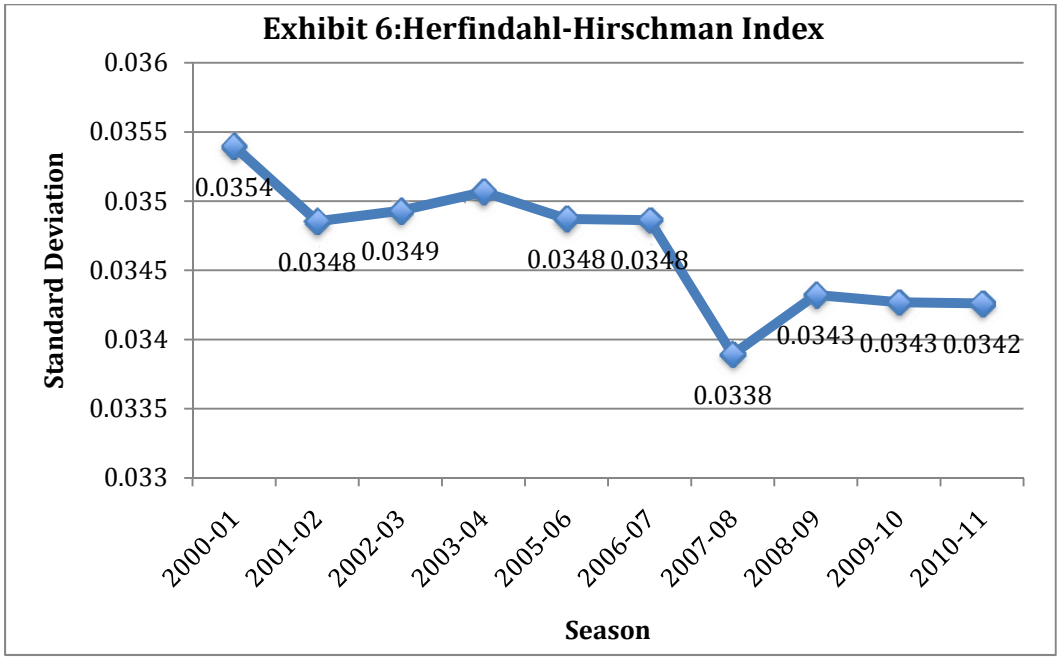


Both of these measures that compare point percentage to an ideal standard provide similar results. They both start right around 2, which is the ratio of actual to ideal standard deviation. In the years up to the lockout, the standard deviation was pretty steady anywhere between 1.7 and 2 for both measures. After the lockout,

when the measures become the same, we can see results that are similar to Exhibit 3. There is a two-year period before the effect kicks in. After the dramatic decrease in the 2007-08 season, it comes back up to right around 1.5.

Herfindahl-Hirschman Index

Next, the Herfindahl-Hirschman (H-H) measure is used. This measure is given by $HHI = \Sigma(W_{it}/\Sigma W_{it})^2$, where W is the number of wins by the i^{th} team in the t^{th} year. This is compared to the total number of wins by all teams. The results are given in Exhibit 6.



The results show that over time, the H-H index has decreased from about .0355 to about .0342 over the ten and a half season spread. Again, this graph shows that there was a two-year layover from the lockout period to where there is a noticeable difference in the results.

Distribution of Wins: Quintile Approach

Next, we evaluate the distribution of wins to determine the change in competitive balance. This measures groups the teams based on number of wins and uses the quintile approach to measure the percentage of wins% that each group accounts for. The results are given in Exhibit 7.

Exhibit 7: Distribution of Wins

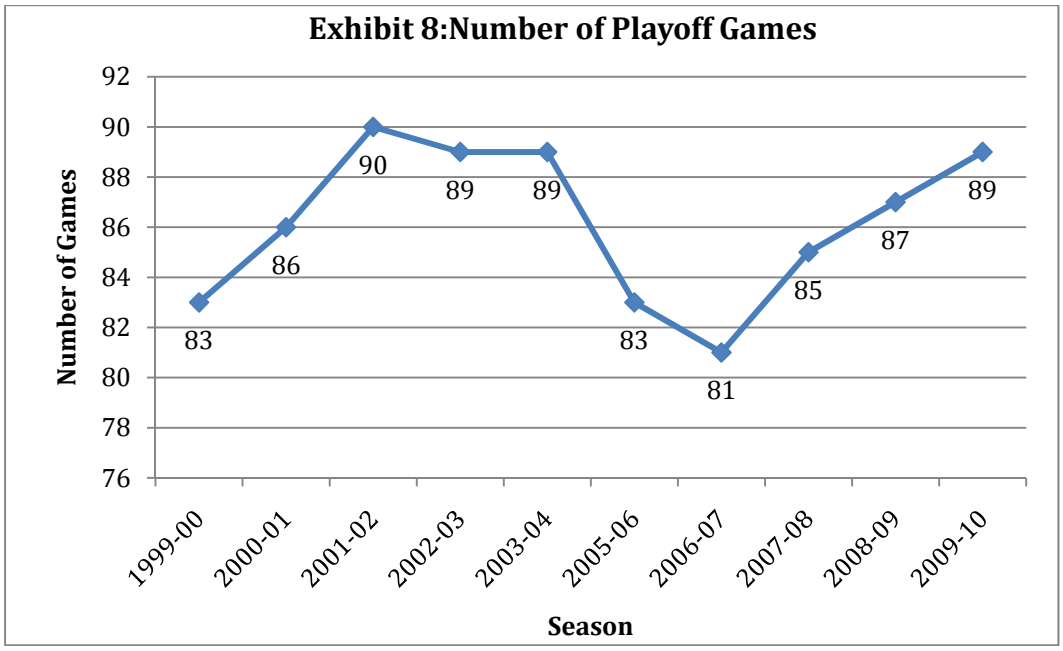
		Percentage of Teams (in order of number of wins)				
		0-20%	21-40%	41-60%	61-80%	81-100%
% of Wins	2000-01	0.129	0.166	0.204	0.23	0.27
	2001-02	0.133	0.18	0.208	0.229	0.25
	2002-03	0.144	0.167	0.194	0.231	0.263
	2003-04	0.132	0.166	0.215	0.233	0.253
	2004-05	NA	NA	NA	NA	NA
	2005-06	0.132	0.187	0.206	0.218	0.257
	2006-07	0.134	0.176	0.208	0.233	0.249
	2007-08	0.162	0.187	0.202	0.213	0.236
	2008-09	0.15	0.184	0.201	0.218	0.247
	2009-10	0.154	0.181	0.197	0.222	0.247
	2010-11	0.153	0.183	0.206	0.216	0.243

This chart shows how the wins are spread out across teams in the NHL. In the seasons before the lockout, the bottom 20% of teams have a small percentage of the total number of wins. It maxes out at 14.4%, but on average is .135. Two years after the lockout, the percentage jumps to 16.2% and does not fall below .15 for the following three seasons. There is also a change in the top 20% of teams. Before the

lockout, the top 20% of teams shared anywhere between 25% and 27% of the wins. Two years after the lockout, this proportion drops down to 23.6% and does not rise above 24.7% for the next three seasons. There is not much change made to the win distribution of teams in the middle, but not much movement is expected. This is because the changes that are made in the 2005 CBA affect the top and bottom teams, but do not effect the middle teams as much.

Number of Playoff Games

The next method deals with the number of playoff games in a season. The measure works by adding the number of games in a playoff year. The results are listed in Exhibit 8.



The number of games is maxed at 90 in the 2001-02 season and minimized at 81 in the 2006-07 season. This is different from previous findings, which shows

improvements in competitive balance. After the lockout, the average number of playoff games is lower than before the lockout, 85 and 87.4 respectively. The number of play-off games has increased each year since the 2006-07 season. However, it cannot be certain that this will continue into following seasons. These results can suggest one of two things. For one, the CBA did not have an effect on the competitive balance of the League. Second, it could be that the League has no trouble with competitive balance in the playoffs. Since the playoffs only include the best teams in the NHL, it has always been competitive. The problem with the balance occurred with the bottom half of the League, or the difference between the top half and the bottom half. If this is the case, then this method does not measure competitive balance in the way that the League wants it.

Playoff Appearances

Next, we will look at the number of times that a team has made the playoffs. For this measure, the Herfindahl-Hirschman Index method is used. This measure is given by $HHI = \Sigma(P_i)^2$, where P is the number of playoff appearances by team i in a five-year span. The results are listed in Exhibit 9.

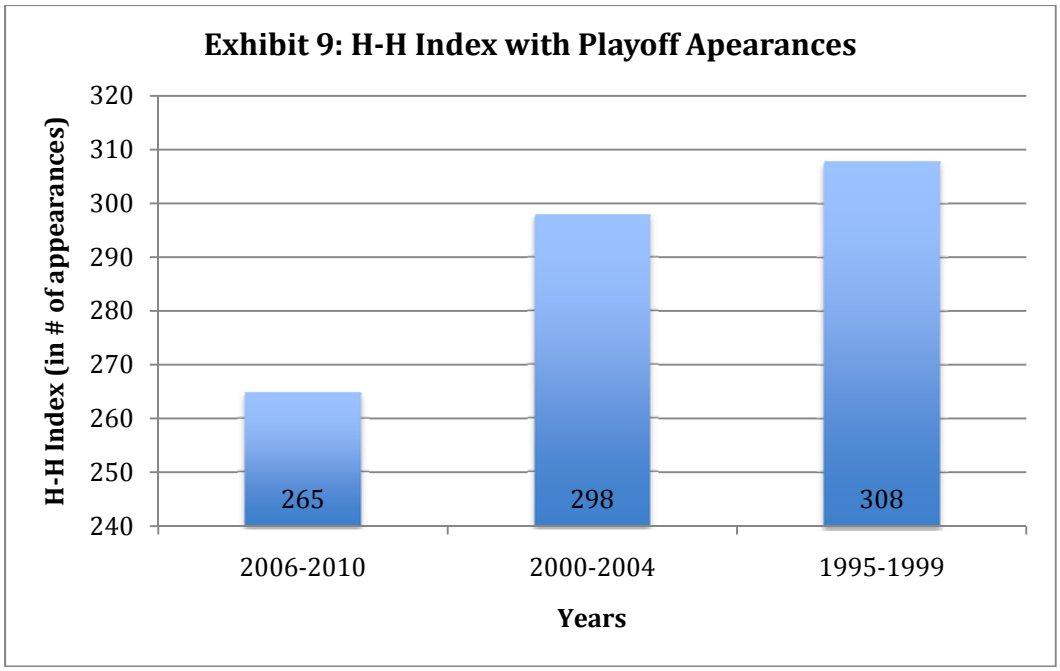


Exhibit 9 shows that the numbers are much lower after the lockout. With this measure, the higher the number, the less competition there is amongst teams to make the playoffs. These results show us that, before the lockout, the same teams would be making the playoffs every year. Now, the number of times a team makes the playoffs is more spread out. This suggests that the League is getting more competitive as different teams are making the playoffs each year.

Previous Point Percentage Measure

The last measure is the impact of a team's point percentage from the prior year on the current year's performance. The results from the regression are given in Exhibit 10.

Exhibit 10: Previous Point Percentage Measure Dependent Variable: PointPct					
	Sample Size	Mean Dependent Variable	C	$PointPct_{-1}$	R^2
Eq. 10.1	145	0.5305	.216 (6.48)	.602 (9.57)	0.391
Eq. 10.2	150	0.5579	.297 (7.79)	.472 (6.9)	0.244

Source: Appendix A

These regression results show the effects of the variable $PointPct_{-1}$ for the seasons before and after the lockout. Before the lockout, the effect that $PointPct_1$ had on the current point percentage (.602) is greater than after the lockout (.457). The regression before the lockout also has a higher R^2 value, .391 compared to .236. In order to see if the difference is statistically significant, a Chow test is used.

In order to run a Chow test, we need a third regression that runs across both time periods. After this, we conduct the following calculation;

$$\frac{(S_C - (S_1 + S_2))/(k)}{(S_1 + S_2)/(N_1 + N_2 - 2k)}.$$

where S_c = Sum of squared residiuals from full time period
S_1 = Sum of squared residuals from period before lockout
S_2 = Sum of squared residuals from period before lockout
N_1 and N_2 = Number of observations in each group
k = total number of parameters

After calculating this, we will compare this value to the F-table to see if we reject the null hypothesis that there is no difference between S_1 and S_2.[13] If we reject it, then there is a statistically significant difference between these two. This tells us that

[13] http://en.wikipedia.org/wiki/Chow_test. Used to acquire equation

there was a change in this $PointPct_{-1}$ in the two time periods. The calculations for this test are given in Exhibit 11

Exhibit 11: Chow Test for Exhibit 10 Regressions

$S_c = .547$
$S_1 = .602 \qquad N_1 = 145$
$S_2 = .457 \qquad N_2 = 150$
$k = 2$

Are null hypothesis is $S1 = S_2$.

Next, we apply these numbers to the following equation

$$\frac{(S_c - (S_1 + S_2)) / k}{(S_1 + S_2) / (N_1 + N_2 - 2K)},$$

$$= \frac{(.547 - (.602 + .457)) / 2}{(.602 + .457) / (150+145-4)}$$

$$= \frac{(.547 - 1.059) / 2}{1.059 / 291}$$

$= -70.34 \qquad F(2, 291) \approx 3$

Since 70.34 > 3, reject the null hypothesis

Regressions used in this model can be found in Appendix B (Equations 10.1, 10.2, 10.3)
The critical F value is taken from the F table[14]

This exhibit shows that the beta values for $Pointct_{-1}$ are statistically different. Thus, there is a difference in the effect that last year's point percentage has on this year's in the two time periods.

[14] Stock and Watson, page 357

Determinants of Competitive Balance

The next step in this chapter is to look at the determinants of competitive balance. The basic regression model is;

$$PointPct = \alpha + \beta_1 Payroll + \beta_2 TFA1 + \beta_3 TFA2 + \beta_4 TFA3 + \varepsilon$$

Where PointPct = Point percentage
Payroll = Payroll
TFA1 = top-end free agent
TFA2 = medium-end free agent
TFA3 = low end free agent

PAYROLL REGRESSIONS

The first set of regressions will look just at payroll and its effect on point percentage. The results are given in Exhibit 12.

Exhibit 12: Payroll Regressions

Dependent Variable: PointPct

	Sample Size	Mean Dependent Variable	C	Payroll	$Payroll^2$	logPayroll	R^2
Eq. 12.1a	148	0.5271	.41 (18.64)	.003 (5.645)			0.17
Eq. 12.1b	150	0.5576	.456 (13.95)	.002 (3.17)			0.063
Eq. 12.2a	148	0.5271	.059 (.815)			.13 (6.4)	0.219
Eq. 12.2b	150	0.5576	.187 (1.67)			.098 (3.33)	0.07
Eq. 12.3a	148	0.5271	.237 (4.14)	.012 (4.29)	-.0001 (-3.256)		0.23
Eq. 12.3b	150	0.5576	0.336 (.167)	.008 (1.36)	0 (-.98)		0.069

Source: Appendix B

Equations 12.1a (pre lockout) and 12.1b (post lockout) demonstrate the relationship if a linear model is used. The R^2 value for the seasons before the lockout is higher than for the seasons after. This means that payroll was a better predictor of point percentage before the lockout. To see if the beta values are different, a Chow test will be used. The results from the Chow test are given in Exhibit 13.

Exhibit 13: Chow Test for Equations 12.1

S_c = .00292
S_1 = ..00309 N_1 = 148
S_2 = ..00224 N_2 = 150
k = 2

Are null hypothesis is S1 = S_2.

Next, we apply these numbers to the following equation

$$\frac{(S_c - (S_1 + S_2)) / k}{(S_1 + S_2) / (N_1 + N_2 - 2K)}$$

$$= \frac{(.00292 - (.00309 + .00224)) / 2}{(.00309 + .00224) / (150+148-4)}$$

$$= \frac{(.00292 - .00533) / 2}{.00533 / 294}$$

= -66.47 F(2, 294) ≈ 3

Since 66.47 > 3, reject the null hypothesis

Regressions used in this model can be found in Appendix C (Equations 12.1a,b,c)
The critical F value is taken from the F table[15]

[15] Stock and Watson, page 357

Exhibit 13 demonstrates that the beta values in Equations 12.1a and 12.1b are different. This tells us that the addition of payroll had a bigger effect on team performance in the seasons before the lockout.

The next two equations look to see if a logarithmic relationship fits better with the two variables. Again, the model that is used is:

$$PointPct = \alpha + \beta_1 LogPayroll$$

This will tell us if there are diminishing returns to payroll. Equation 12.2a includes the seasons before the lockout. This regression gives beta value for logPayroll of .13. This means that a 1% increase in payroll leads to an increase in point percentage of .13. These results suggest that if a team were to raise payroll by 10%, which is a likely scenario, then they would increase their point percentage by 1.3. Point percentage cannot be more than 1, so this is impossible. The same is true for equation 12.2b. This tells us that a logarithmic relationship is not an accurate portrayal of the true story.

The final two equations experiment with a quadratic relationship. Again, this model is:

$$PointPct = \alpha + \beta_1 Payroll + \beta_2 Payroll^2$$

The hypothesis is that there are diminishing returns to the amount of money that is spent on payroll. Equation 12.3a demonstrates that, for every million dollars that a team spends on payroll, the point percentage will go up. However, with each additional million, it will increase by a lesser amount. This means that the effect of increasing payroll from $25 million to $30 million will have a bigger effect on winning percentage than an increase from $40 million to $45 million, prior to the

lockout. Although this effect exists, it does not seem to be large. The R^2 value demonstrates that this is the most accurate relationship (in the pre-lockout era) of the ones explored. For equation 12.3b (post lockout), the same effect does not exist. This could suggest that in the seasons after the lockout, the impact of payroll is negligible. This is supported by the low R^2 value of equation 12.3b.

Free Agency Impact

The next set of regressions includes free agent singings in the model. All of the following equations are only for the seasons after the lockout. This is because the data for free agents signed could not be found for the seasons before the lockout. The free agency signings are split into three groups, based on their salary. Low-end players (TFA3) will consist of players signed for under one million dollars. Medium-end players (TFA2) will be players making between one and four million dollars per year. The high-end players (TFA3) will be the players making over four million dollars. The system is a little different for goalies. Starters will be in the top group, back-ups will be in the medium group, and any other goalie will be in the third group. In doing this, we can see if there is a difference as to which players a team targets in free agency. The regression results are reported in Exhibit 14.

Exhibit 14: Model Statement Regressions

Dependent Variable: PointPct

	Sample Size	Mean Dependent Variable	C	Payroll	TFA_1	TFA_2	TFA_3	R^2
Eq. 14.1	150	0.5576	.492 (15.42)	0.002 (3.15)	.015 (2.29)	-0.002 (-0527)	-0.011 (-3.499)	0.195
Eq. 14.2	150	0.5576	.459 (14.26)	.0016 (2.28)	.016 (2.38)			0.098
Eq. 14.3	150	0.5576	.488 (15.57	.0022 (3.13)	.015 (2.26)		-.011 (-4.15)	0.193

Source: Appendix C

The regressions in these groups all give similar results for certain variables. Equation 14.1 shows that the variables Payroll and TFA_1 have a positive and significant effect on point percentage. The variable TFA_3 has a negative effect. This tells us that spending more money on payroll and the addition of top-end free agents all increase a team's point percentage (.002 for every million and .015 for each free agent signed). Also, signing a low-end free agent will decrease a team's point percentage by .011. This equation has an R^2 value of .195, suggesting that there are many more variables that have an effect on a team's point percentage. The next equation, Eq. 14.2, takes out the effect of signing low-end and medium-end players, which results in an even lower R^2 value. This does not change the effects of payroll and TFA_1. Equation 14.3 gives only the variables that are statistically significant, and is still similar to the equation containing all of the variables. It also has a similar R^2 value, .193, to equation 14.1.

In general, these regressions tell us that the addition of a high-end free agent will increase the number of wins by about 1.2, which is equivalent to about 2.46

points in the standings. If a team were to have signed just 2 top-end players, this would increase their win total by 2 or 3 games, which is the equivalent of about 5 points in the standings. This may not seem like it is worth it, but 5 points is a big difference for some teams. Exhibit 15 demonstrates this difference.

Exhibit 15: The Effect of Five Points on Playoff Teams					
Season	09-10	08-09	07-08	06-07	05-06
Teams within 5 points of making playoffs	3	4	5	4	3
Teams within 5 points of increasing playoff seed	10	8	9	8	8

From this exhibit, it is clear that 5 points in the standings can make a big difference for some teams. There are only 16 teams that make the playoffs. In the past 5 years, at least half of the playoff teams were within five points of increasing their playoff seeds. This shows how close these teams are together. Effective free agent signing can put a team ahead of the pack in these close scenarios. These regressions also show the negative effects of signing a low-end free agent. These low-end players are often players who do not play in the NHL. Signing these players uses up resources that could be used to sign top-end free agents or help in other ways.

Chapter 5
Interpretation of Findings and Conclusion

In this chapter, we interpret the findings on the measures and determinants of competitive balance and conclude that the League's competitive balance improved as a result of the 2005 CBA. The impact of these changes in the CBA allowed all teams to sign players of talent, leading to an increased in competitive balance. We end this chapter with limitations of this study and suggestions for future research

Interpretation of Findings

Measures of Competitive Balance

Three different measures of a teams point percentage indicate that there has been a decrease in the dispersion of point percentage across the League.
The next two measures use the distribution of wins across teams. The H-H index reduced, suggesting an increase in competitive balance. The quintile approach shows that the distribution of wins became more uniform as a result of the 2005 CBA. The next two measures used the playoffs as a measure. The number of playoff games showed no change in the seasons after the lockout. However, the H-H index measuring the number of playoff appearances greatly decreased after the lockout. This means different teams are making the playoffs each year. The final measure is the effect that last year's performance had on this years. The results show that this effect is lower in the seasons after the lockout, suggesting more change in the rankings from year to year.

In total, eight different measures were used as alternative measures of competitive balance. Seven of these eight showed increases in competitive balance. Some of these measures took a couple of seasons after the lockout to show a change. This lag in the results is likely due to the amount of time it took for these effects to take place. The changes that were made were not instantaneous changes. It would take time for weaker teams to build a better team through free agency and spending money received through the revenue sharing plan. Also, even though some of the changes demonstrated are not substantial, the League is better than where it was before the lockout. This means the NHL has taken a step in the right direction with the 2005 CBA and, as a result, the competitive balance of the League has improved.

Determinants of Competitive Balance

The first regressions experimented with the effect that payroll has on a team's point percentage. In each case looked at, payroll had less of an effect on team's point percentage in the seasons after the lockout. This means that after the lockout, the effect of spending more money has less effect on the success of the team. Before the lockout, teams would spend lots of money to make the best team. With the institution of the salary cap, this is no longer possible. By limiting the payroll of teams, and the inclusion of new revenue sharing plan, the dispersion of payroll has decreased.

The next set of regressions include the free agent variables as well as payroll. All of these regressions are from after the lockout. Here, we see a positive effect of signing a top-end free agent, and a negative effect of signing a low-end free agent.

Although the impact of these signings on performance seem low, it can be the difference between making the playoffs and missing them. In the eyes of fans and managers, this is a huge difference.

From these two sets of regressions, we can draw some conclusions on the determinants of competitive balance that this paper tested. For one, payroll does have a positive effect on a team's point percentage. This effect has decreased since the 2005 CBA. Teams that go out and spend money will increase their team's performance, but can only do so by so much. The spread of payroll across teams is certainly one of the controlling factors of competitive balance. Also, the signing of top-end free agents has shown to increase a team's point percentage. Free agents can sign with any team, so long as they have the cap room to do so. This gives weaker teams a chance to sign some top-end free agents to increase their team's performance. Free agency signings is also a key determinant of competitive balance.

Conclusion

We conclude that competitive balance has increased as a result of the new NHL Collective Bargaining Agreement. These changes are due to the institution of the salary cap, changes in free agency rules, and the new revenue sharing plan. The salary cap has shown to bring teams' payrolls closer together which has lowered the effect that payroll has on performance. The changes in free agency rules have helped teams to sign younger and better players. This can help a team to increase its performance over the course of a couple years, as long as they are signing top-end players. Finally, the revenue sharing plan has helped increase the competitive

balance of the League. With poorer teams getting money, they are able to spend it on signing free agents and bring up their payroll so it is closer to the rest of the League. These three changes are some of the driving forces that have led to an increase in the competitive balance of the NHL.

The findings of this paper are important for many reasons. First, one of the main goals of the 2005 CBA was to increase the competitive balance of the League. That is why rules were introduced that would help weaker and poorer teams perform better and put limits on the stronger and richer teams. The findings of this paper suggest that the League has accomplished its goal. As the competitiveness of the League has increased, so too have the ratings. Every playoff year since the lockout, there have been reports that television ratings have reached new heights. This is a great sign for the NHL as they look to continue its success into the future.

This also important as the 2005 CBA agreement will expire after the 2011-2012 season, about a year and three months away. As this time gets closer, the NHL and NHLPA will look at the current state of the NHL to see if the changes that were made in the last CBA worked or not. This type of research will help them answer these questions. Also, it is possible that they can change the rules even more if they want more competitive balance in the NHL. Examples for this would be to lower the age of unrestricted free agents even more or increase the amount of revenue sharing.

There are a few limitations to this study. For one, free agency signings was not acquired for the years before the lockout. This information would have been helpful for comparison to see if the changes made any difference or not. Also, there

was no real way to look at the effects that revenue sharing had for the teams that received it, as there was no apparent way to test this. As a result, this paper just assumed that teams were able to spend the money they received to increase payroll and possibly sign free agents.

In conclusion, no matter the measure used, competitive balanced increased as a result of the 2005 CBA. The impact of the salary cap, revenue sharing, and free agency rule changes equalized a team's capacity to sign players of talent. This prevented stronger teams from acquiring all the talent and made the weaker teams more competitive, which is why the overall competitive balance improved. Going forward, these changes in the CBA should be preserved if the League is going to continue to improve its competitive balance.

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Appendix A

Equation 10.1

$PointPct = \alpha + \beta_1 PointPct_{-1}$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Date: 02/15/11 Time: 12:09
Sample: 2000 2004
Periods included: 5
Cross-sections included: 30
Total panel (unbalanced) observations: 145

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$POINTPCT_{-1}$	0.602251	0.062896	9.575339	0.0000
C	0.216400	0.033374	6.484029	0.0000

R-squared	0.390678	Mean dependent var	0.530517
Adjusted R-squared	0.386417	S.D. dependent var	0.094366
S.E. of regression	0.073919	Akaike info criterion	-2.358010
Sum squared resid	0.781345	Schwarz criterion	-2.316951
Log likelihood	172.9557	Hannan-Quinn criter.	-2.341326
F-statistic	91.68712	Durbin-Watson stat	2.363822
Prob(F-statistic)	0.000000		

Equation 10.2

$PointPct = \alpha + \beta_1 PointPct_{-1}$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Date: 03/04/11 Time: 18:10
Sample: 2007 2011
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PREVPOINTPCT	0.457687	0.067544	6.776148	0.0000
C	0.302678	0.038097	7.944943	0.0000

R-squared	0.236784	Mean dependent var	0.557893
Adjusted R-squared	0.231627	S.D. dependent var	0.080041
S.E. of regression	0.070162	Akaike info criterion	-2.462787
Sum squared resid	0.728553	Schwarz criterion	-2.422645
Log likelihood	186.7090	Hannan-Quinn criter.	-2.446478
F-statistic	45.91618	Durbin-Watson stat	1.944366
Prob(F-statistic)	0.000000		

Equation 10.3

$PointPct = \alpha + \beta_1 PointPct_{-1}$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Date: 03/04/11 Time: 18:07
Sample: 2000 2011
Periods included: 10
Cross-sections included: 30
Total panel (unbalanced) observations: 295

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PREVPOINTPCT	0.547116	0.045155	12.11631	0.0000
C	0.249049	0.024739	10.06699	0.0000

R-squared	0.333796	Mean dependent var	0.544437
Adjusted R-squared	0.331522	S.D. dependent var	0.088298
S.E. of regression	0.072192	Akaike info criterion	-2.412205
Sum squared resid	1.527045	Schwarz criterion	-2.387208
Log likelihood	357.8002	Hannan-Quinn criter.	-2.402195
F-statistic	146.8050	Durbin-Watson stat	2.085300
Prob(F-statistic)	0.000000		

Appendix B

Equation 12.1a

$PointPct = \alpha + \beta_1 Payroll$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2000 2004
Periods included: 5
Cross-sections included: 30
Total panel (unbalanced) observations: 148

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.003088	0.000547	5.645322	0.0000
C	0.409911	0.021993	18.63825	0.0000

R-squared	0.179174	Mean dependent var	0.527101
Adjusted R-squared	0.173552	S.D. dependent var	0.097206
S.E. of regression	0.088369	Akaike info criterion	-2.001160
Sum squared resid	1.140136	Schwarz criterion	-1.960657
Log likelihood	150.0859	Hannan-Quinn criter.	-1.984704
F-statistic	31.86966	Durbin-Watson stat	0.961259
Prob(F-statistic)	0.000000		

Equation 12.1b

$PointPct = \alpha + \beta_1 Payroll$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2006 2010
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.002238	0.000706	3.170579	0.0018
C	0.456162	0.032703	13.94847	0.0000

R-squared	0.063603	Mean dependent var	0.557620
Adjusted R-squared	0.057276	S.D. dependent var	0.085098
S.E. of regression	0.082625	Akaike info criterion	-2.135756
Sum squared resid	1.010389	Schwarz criterion	-2.095614
Log likelihood	162.1817	Hannan-Quinn criter.	-2.119448
F-statistic	10.05257	Durbin-Watson stat	1.030052
Prob(F-statistic)	0.001849		

Equation 12.1c

PointPct = $\alpha + \beta_1$Payroll

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2000 2010
Periods included: 10
Cross-sections included: 30
Total panel (unbalanced) observations: 298

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.002919	0.000408	7.151551	0.0000
C	0.420832	0.017714	23.75702	0.0000

R-squared	0.147330	Mean dependent var	0.542463
Adjusted R-squared	0.144449	S.D. dependent var	0.092431
S.E. of regression	0.085495	Akaike info criterion	-2.074030
Sum squared resid	2.163578	Schwarz criterion	-2.049218
Log likelihood	311.0305	Hannan-Quinn criter.	-2.064098
F-statistic	51.14469	Durbin-Watson stat	1.027127
Prob(F-statistic)	0.000000		

Equation 12.2a

PointPct = $\alpha + \beta_1$logPayroll

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2000 2004
Periods included: 5
Cross-sections included: 30
Total panel (unbalanced) observations: 148

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPAYROLL	0.130662	0.020413	6.401071	0.0000
C	0.059791	0.073348	0.815165	0.4163

R-squared	0.219142	Mean dependent var	0.527101
Adjusted R-squared	0.213793	S.D. dependent var	0.097206
S.E. of regression	0.086191	Akaike info criterion	-2.051077
Sum squared resid	1.084621	Schwarz criterion	-2.010574
Log likelihood	153.7797	Hannan-Quinn criter.	-2.034621
F-statistic	40.97371	Durbin-Watson stat	0.997904
Prob(F-statistic)	0.000000		

Equation 12.2b

PointPct = $\alpha + \beta_1$logPayroll

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2006 2010
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPAYROLL	0.097933	0.029396	3.331552	0.0011
C	0.186484	0.111603	1.670956	0.0968

R-squared	0.069763	Mean dependent var	0.557620
Adjusted R-squared	0.063478	S.D. dependent var	0.085098
S.E. of regression	0.082353	Akaike info criterion	-2.142357
Sum squared resid	1.003742	Schwarz criterion	-2.102215
Log likelihood	162.6768	Hannan-Quinn criter.	-2.126048
F-statistic	11.09924	Durbin-Watson stat	1.034178
Prob(F-statistic)	0.001091		

Equation 12.3a

$PointPct = \alpha + \beta_1 Payroll + \beta_2 Payroll^2$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Date: 02/15/11 Time: 12:19
Sample: 2000 2004
Periods included: 5
Cross-sections included: 30
Total panel (unbalanced) observations: 148

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.012117	0.002823	4.291831	0.0000
PAYROLLSQUARED	-0.000105	3.23E-05	-3.255836	0.0014
C	0.237161	0.057176	4.147918	0.0001

R-squared	0.235094	Mean dependent var	0.527101
Adjusted R-squared	0.224544	S.D. dependent var	0.097206
S.E. of regression	0.085600	Akaike info criterion	-2.058205
Sum squared resid	1.062463	Schwarz criterion	-1.997450
Log likelihood	155.3071	Hannan-Quinn criter.	-2.033520
F-statistic	22.28288	Durbin-Watson stat	1.011861
Prob(F-statistic)	0.000000		

Equation 12.3b

$PointPct = \alpha + \beta_1 Payroll + \beta_2 Payroll^2$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2006 2010
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.007979	0.005858	1.362091	0.1753
PAYROLLSQUARED	-6.52E-05	6.60E-05	-0.987323	0.3251
C	0.335812	0.126206	2.660815	0.0087

R-squared	0.069771	Mean dependent var	0.557620
Adjusted R-squared	0.057115	S.D. dependent var	0.085098
S.E. of regression	0.082632	Akaike info criterion	-2.129032
Sum squared resid	1.003733	Schwarz criterion	-2.068820
Log likelihood	162.6774	Hannan-Quinn criter.	-2.104570
F-statistic	5.512833	Durbin-Watson stat	1.037726
Prob(F-statistic)	0.004913		

Appendix C

Equation 14.1

$PointPct = \alpha + \beta_1 Payroll + \beta_2 TFA1 + \beta_3 TFA2 + \beta_4 TFA3$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Sample: 2006 2010
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.002250	0.000713	3.157343	0.0019
TFA1	0.015082	0.006594	2.287026	0.0236
TFA2	-0.001989	0.003772	-0.527346	0.5988
TFA3	-0.010890	0.003112	-3.499738	0.0006
C	0.491602	0.031886	15.41733	0.0000

R-squared	0.195007	Mean dependent var	0.557620
Adjusted R-squared	0.172800	S.D. dependent var	0.085098
S.E. of regression	0.077397	Akaike info criterion	-2.246962
Sum squared resid	0.868602	Schwarz criterion	-2.146607
Log likelihood	173.5221	Hannan-Quinn criter.	-2.206191
F-statistic	8.781423	Durbin-Watson stat	1.144001
Prob(F-statistic)	0.000002		

Equation 14.2

$PointPct = \alpha + \beta_1 Payroll + \beta_2 TFA1$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Date: 02/22/11 Time: 10:52
Sample: 2006 2010
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.001678	0.000733	2.288112	0.0236
TFA1	0.016443	0.006906	2.381135	0.0185
C	0.459817	0.032236	14.26413	0.0000

R-squared	0.098378	Mean dependent var	0.557620
Adjusted R-squared	0.086111	S.D. dependent var	0.085098
S.E. of regression	0.081352	Akaike info criterion	-2.160268
Sum squared resid	0.972865	Schwarz criterion	-2.100055
Log likelihood	165.0201	Hannan-Quinn criter.	-2.135805
F-statistic	8.019779	Durbin-Watson stat	1.075192
Prob(F-statistic)	0.000495		

Equation 14.3

$PointPct = \alpha + \beta_1 Payroll + \beta_2 TFA1 + \beta_3 TFA3$

Dependent Variable: POINTPCT
Method: Panel Least Squares
Date: 02/22/11 Time: 10:53
Sample: 2006 2010
Periods included: 5
Cross-sections included: 30
Total panel (balanced) observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PAYROLL	0.002216	0.000708	3.130047	0.0021
TFA1	0.014860	0.006565	2.263612	0.0251
TFA3	-0.011602	0.002796	-4.148764	0.0001
C	0.488868	0.031384	15.57691	0.0000

R-squared	0.193463	Mean dependent var	0.557620
Adjusted R-squared	0.176890	S.D. dependent var	0.085098
S.E. of regression	0.077206	Akaike info criterion	-2.258379
Sum squared resid	0.870268	Schwarz criterion	-2.178096
Log likelihood	173.3784	Hannan-Quinn criter.	-2.225763
F-statistic	11.67359	Durbin-Watson stat	1.144415
Prob(F-statistic)	0.000001		